

CQSDI Panel

Quality Tasks on the Left Side of the Systems Engineering V

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Source: NASA.gov



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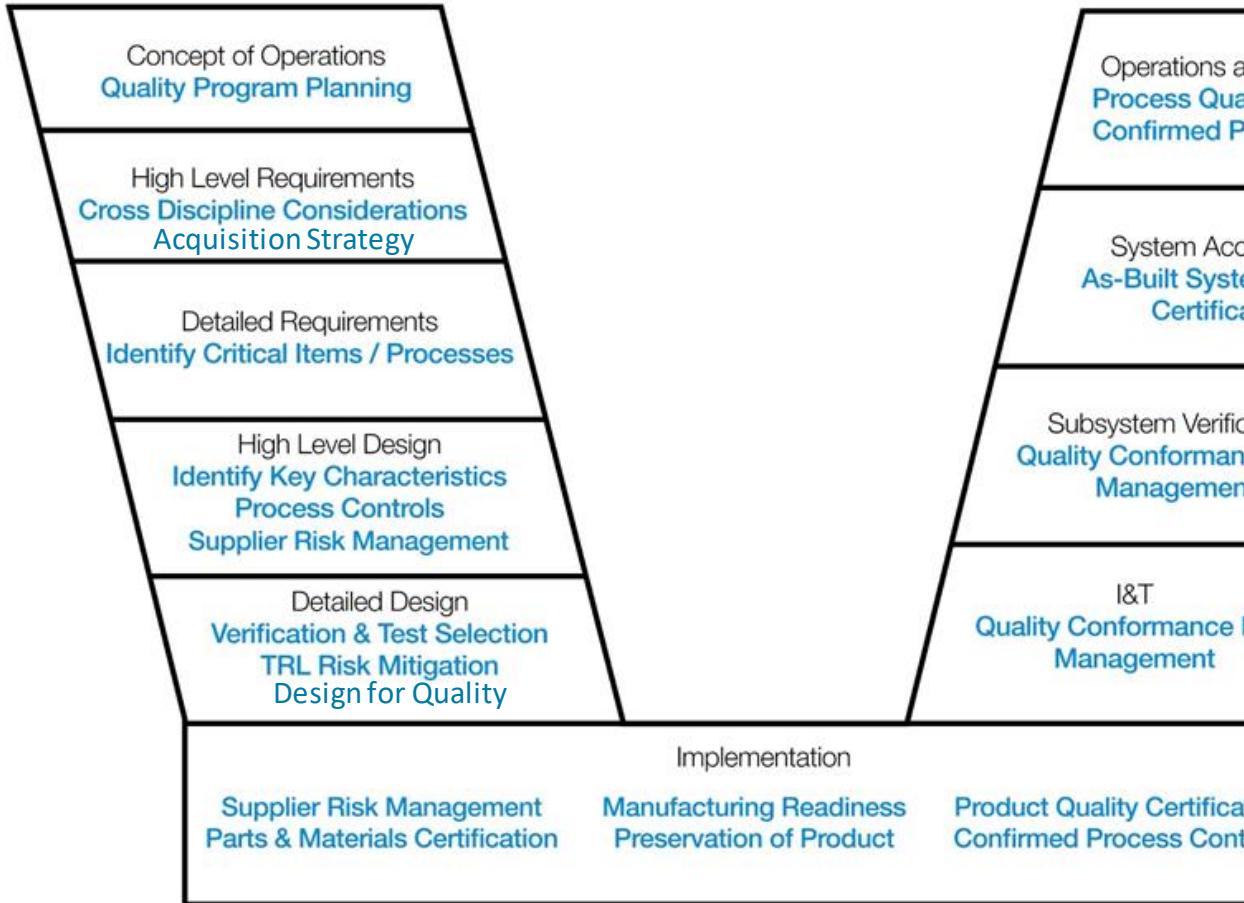


Source: NASA.gov

- Why “Get in Early”? Why hasn’t the problem been solved already?
- What does “Early” mean within the scope of Quality Assurance at NASA?

What lifecycle? What is “early”?

Systems Engineering / Quality Engineering



Systems Engineering / Quality Assurance



What problem are you trying to solve?

Drivers of Stochastic Conditions in NASA Quality Environment

- CST, Leveraging COTS
- Using Low TRL Items and Processes
- Supply Chain Disruptions
- Ultra-low volume
- Quality as a substitute for reliability

Early lifecycle contribution by QE/QA mitigates the related risks: COST and SCHEDULE

COTS: Commercial Off the Shelf

TRL: Technical Readiness Level

CST: Commercial Space Transportation

Why hasn't this problem been solved already?

3.1 Outline. The contractor shall maintain an effective and economical quality control system planned and developed in conjunction with other planning functions. The system, including procedures, shall be adjusted to suit the type and phase (research, development, production) of procurement. The system shall be based upon consideration of the complexity of product design, quantity under procurement, interchangeability and reliability requirements, and manufacturing techniques. The system shall assure that adequate control of quality is maintained throughout all areas of contract performance, including, as applicable, the receipt, identification, stocking and issue of material, and the entire process of manufacture, packaging, shipping, storage and maintenance. All supplies or services under the contract, whether manufactured or performed within the contractor's plant or at any other source, shall be subject to control at such points as necessary to assure conformance to contractual requirements. The system shall provide for the prevention and ready detection of discrepancies and for timely and positive corrective action. The contractor shall make objective evidence of quality conformance readily available to the Government representative.

← **The contractor shall**

Quality system tailored for type of work: R&D, Dev, Production, Complex, Reliability needs, Type of Processes

Lifecycle: receipt, stocking, production, shipping, storage

Applies across supply chain

Find and correct defects

Collect objective evidence of conformance

MIL-Q-9858

9 APRIL 1959

SUPERSEDING

MIL-G-14461 (ORD)

10 JANUARY 1957

MIL-Q-5923C (USAF)

16 MARCH 1956

MILITARY SPECIFICATION

QUALITY CONTROL SYSTEM REQUIREMENTS

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

← Much of this text can be found in FAR Part 46.

CHAPTER 2: COMPLETE MASTER LIST OF NASA MANAGEMENT DIRECTIVES

(AS OF AUGUST 1, 1982)			
ISSUANCE NO	EFF REV/VAL DATES	SUBJECT TITLE	
NHB 5300.4(1A)	APR 1 1970	Reliability Program Provisions for Aeronautical and Space Systems (Formerly NPC 250 1) (To Order See Chapt 4)	
NHB 5300.4(1B)	APR 1 1969	Quality Program Provisions for Aeronautical and Space Systems (Formerly NPC 200 2) (To Order See Chapt 4)	
NHB 5300.4(1C)	JUL 1971	Inspection System Provisions for Aeronautical and Space System Parts Components and Services (Formerly NPC 200 3) (To Chapt 4)	
NHB 5300.4(1D 2)	OCT 1 1979	Safety Reliability Maintainability and Quality Provisions for the Space Shuttle Program (To Order See Chapt 4)	

6000 6999 INDUSTRY AFFAIRS



- QMS concept is strengthening quality control and assurance as an institutional function.
- Still focused on supplier's responsibilities
- Lacks QA influence/contribution to risk management:
 - Supplier: SCRM
 - Quality: Process Capabilities, Manufacturability
 - Technology: TRL, Manufacturability

NHB 5300.4 (1B) Quality Program Provisions For Aeronautical and Space System Contractors (1962)

NHB 5300.4 (1C) Inspection System Provisions for Aeronautical and Space System Contractors

What's old is new

NASA QUALITY REQUIREMENTS & COST CONTROL

by
Howard M. Weiss, Chief, Quality Assurance Division
Office of Reliability & Quality Assurance
NASA Headquarters, Washington, D.C.

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NASA
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NASA's Quality Program is one of several technical disciplines necessary to the successful development and space flight operation of the small quantities of inherently costly research-type hardware through which man is conquering space. Reference (2) describes features of the Quality Program, including the application of Quality Publications, NPC 200-2 & 200-3, to NASA procurements.

NATURE OF QUALITY REQUIREMENTS

To understand NASA quality requirements it is helpful to consider first that NPC 200-2 establishes broad, quality system requirements for space system contractors and that NPC 200-3 does the same for suppliers operating below the system level. The principles expressed in these Quality Publications:

- Encourage industry initiative in achieving quality and in developing objective evidence of quality.
- Permit use of those existing industry procedures found suitable for space quality, either as is, or with modifications.

- Require deliberate management effort in many quality functions, including but not limited to traditional quality control and inspection.
- Permit variations in detailed effort to be tailored to the circumstances of individual procurements.
- Provide for a firm understanding of quality requirements prior to NASA purchase and definition of quality requirements in subsequent subcontracts.
- Require control from initiation of design through to operational use.
- Provide for early problem recognition and solution to avoid the cost and schedule impact of problem solutions delayed to the end-item test or launch site.
- Provide for personnel accountability and responsibility through identification of the worker with his work, training and certification.

These principles are intended primarily to help ensure mission success and flight crew safety. They offer identifiable opportunities for cost control in quality operations for NASA, both by suppliers and by the Research and Space Flight Centers exercising technical direction over NASA contracts. Both industry



NASA Procedural Requirements

COMPLIANCE IS MANDATORY

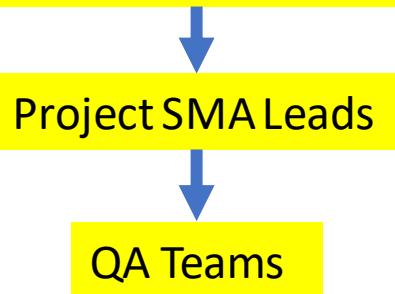
NPR 8735.2B

Effective Date: August 12, 2013
Expiration Date: December 12, 2019

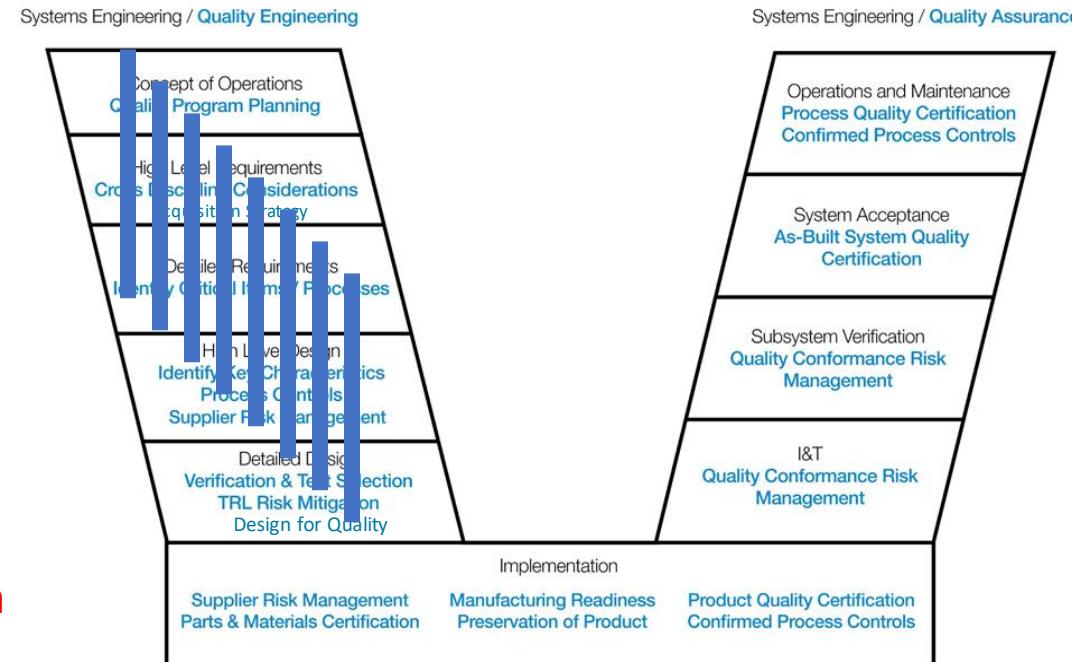
Management of Government Quality Assurance Functions for NASA Contracts

Responsible Office: Office of Safety and Mission Assurance

- Good Requirements Levied on Contracts
- Verify Compliance to Requirements



How do we remove these blind spots and missed opportunities where QA can build in quality and mitigate cost risk?



How do we pull out of the trench and up into the earlier, research, study, and planning steps?

Systems Engineering / Quality Engineering

1 Understand the mission context: Primary mission objectives and risk posture

Crew-based objectives?

Space Science?

Weather?

Aeronautics?

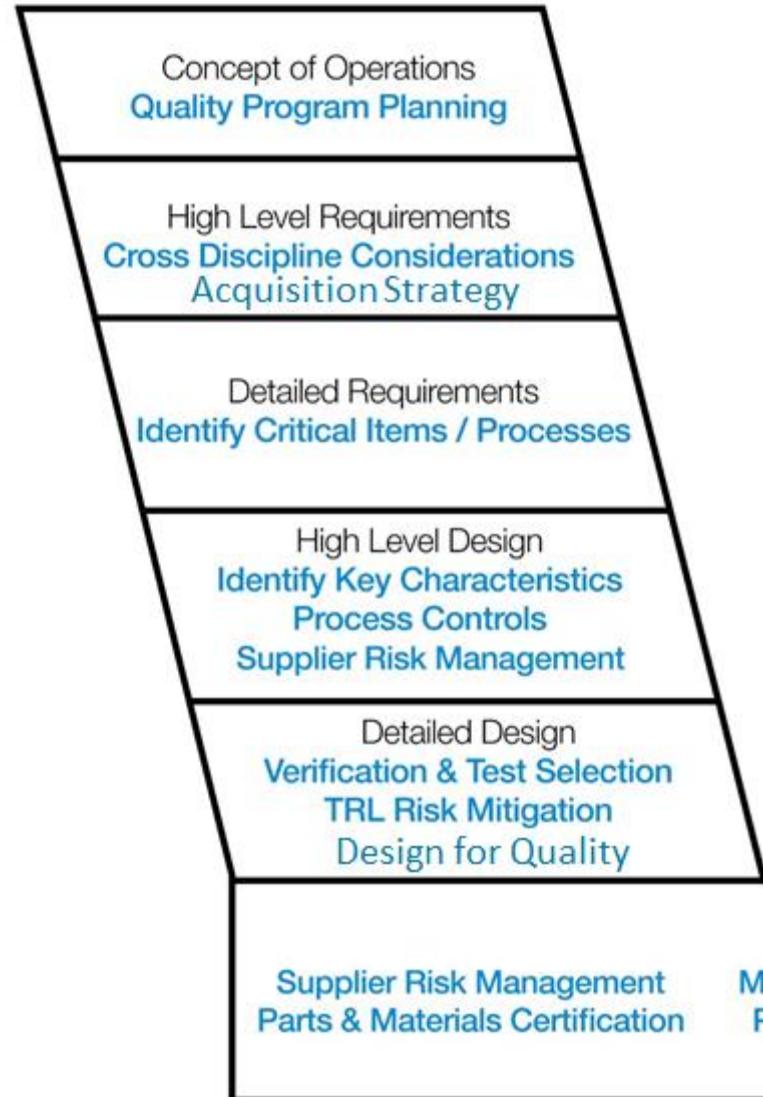
Risk rating: A, B, C, D, R&D?

Schedule drivers?

Technology dependencies?

Key science, technology, business partners?

NASA Quality Policy, NPR 8735.2C now describes flexibilities associated with tailoring based on mission objectives and risk posture.



Where is there Flexibility for Tailoring? (aka Risk Trade Space)

Mission Success Objective	Human Rated	Class A/B	Class C/D	7120.8	Airworthiness
Crew Safety	Low	na	na	na	Low
Technical/Space Science	na	Low	Low to Med	High	na
Technical/Engineering Dev	Med to High	Med to High	Low to Med	High	Low
Programmatic	High	High	Low to Med	Low	High
Regulatory and Other Stakeholders' Requirements	Low	Low	Low	Low	Low

Safety certification is crucial

- Crew Safety: No serious injury to astronauts or pilots
- Technical/Science: Acquisition of mission science data
- Technical/Engineering: Successful TRL growth for new hardware and software designs
- Programmatic: Meet budget commitment (loss of schedule realized as cost growth)
- Regulatory and Other Stakeholders': Constraints set by external authorities; Laws, regulations, treaties, Do No Harm to externally owned assets (e.g., another project, a private entity, another space agency)

Staying in budget is more important than some technical objectives

RISK-BASED QUALITY STRATEGY

QA's research and recommendations should be heavily influenced by the mission objectives and risk context.

Show you can communicate and recommend effectively within the mission success context.

ASK → How will the project decide what is critical vs not as critical? [See NPR 8735.2C, 4.1.4]

→ What tradeoffs are being made by designers and technology developers? Is there an opportunity for Quality to soften those risks? [See NPR 8735.2C, 4.3]

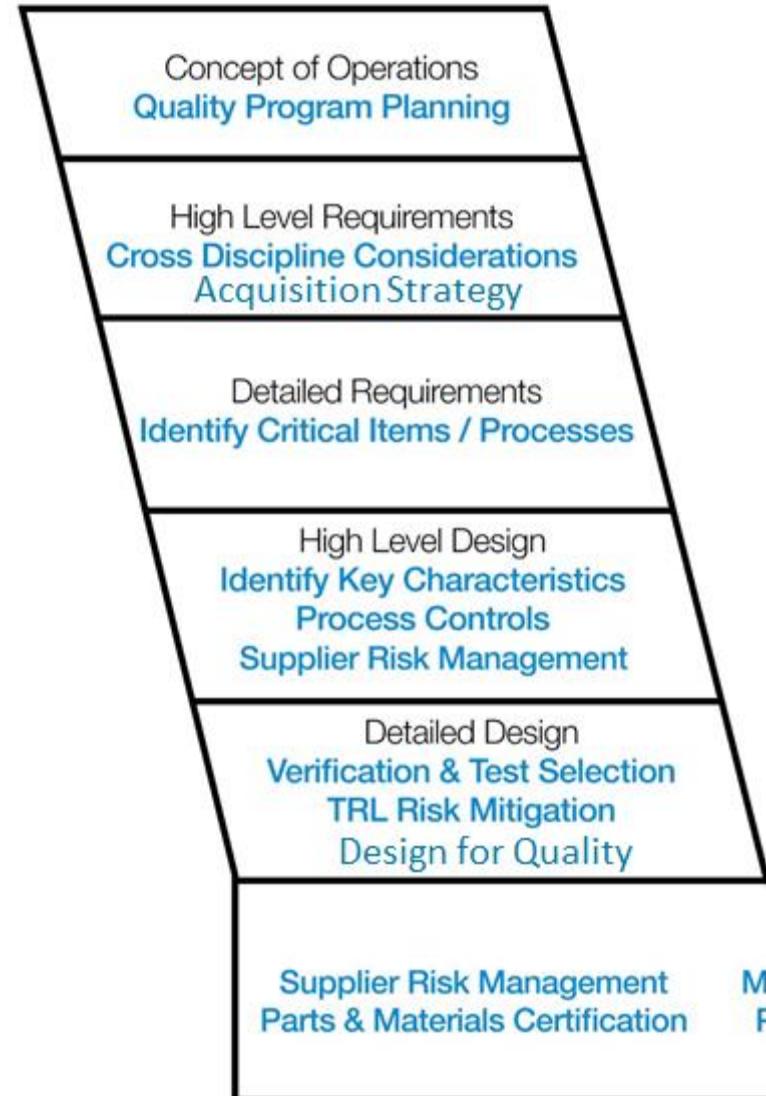
→ Where are the Quality “must haves” demanded by regulations or external requirements?

Mission Success Objective	Human Rated	Class A/B	Class C/D	7120.8	Airworthiness
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- 1 Understand the mission context: Primary mission objectives and risk posture
- 2 Understand acquisition strategy drivers and SCRM implications



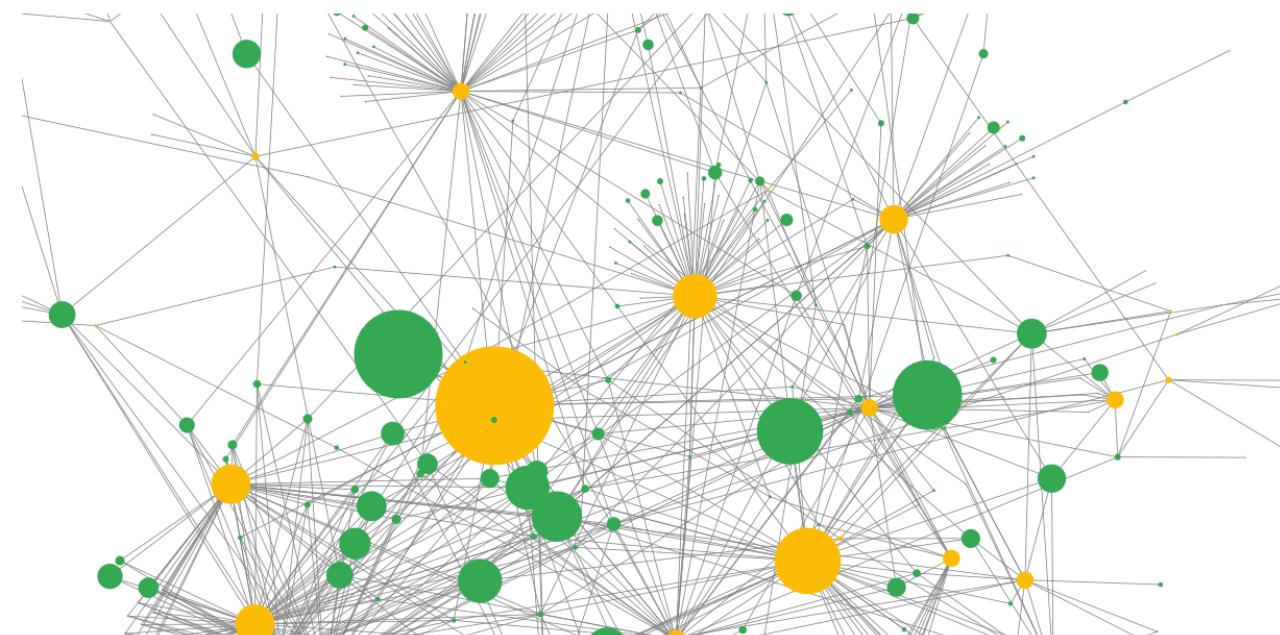
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What are the strategic supply chain drivers?

- Make vs Buy
- Leveraging heritage hardware
- Prior TRL developments
- Sole source
- Multi-step procurement

Where are:

- Updated designs
- Retail, Military, Aerospace COTS
- Low TRL products
- Dependence on diminishing sources



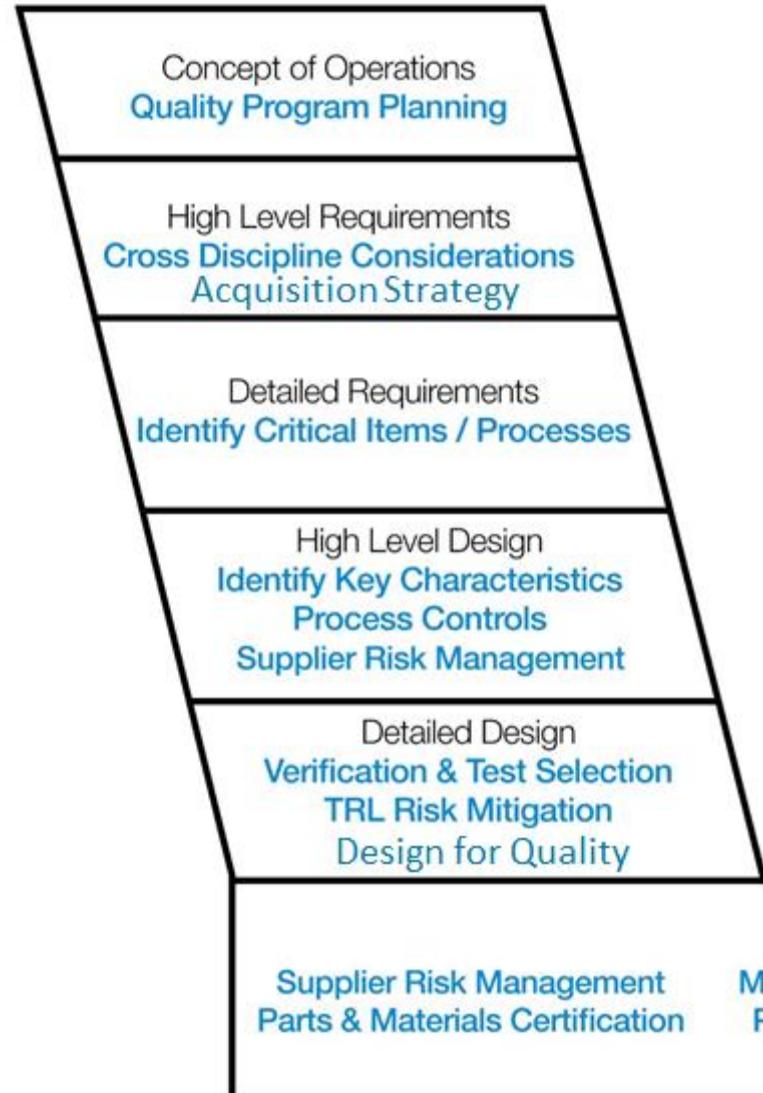
Start Building Your Supply Chain Knowledge

- Look at and improve SCRM data acquisition systems and interoperability
- Build reusable approaches to routine metric reporting on SCRM health and risks
- Create a supplier map or other data set with known or likely suppliers.
- Refresh your awareness of reported concerns: GIDEP, OASIS, Nadcap, SCIC (NASA only), Bloomberg.
- >>Scrutinize how Prime will perform subtler supplier control<<
- Begin recommending supplier audits or assessments based on factors above or results of research.
- Feed supplier research results into discussions about MRB and change approval delegation.

How do we pull out of the trench and up into the earlier, research, study, and planning steps?

Systems Engineering / Quality Engineering

- 1 Understand the mission context: Primary mission objectives and risk posture
- 2 Understand acquisition strategy drivers, research Supply Chain risk, and recommend SCRM activities
- 3 Provide for good requirements flowdown past the Prime and Major Subcontractors



How will you create requirements language to ensure the sufficient QMS or quality control requirements are pushed down the supply chain?

- Simply flowing down AS9100 **will not force the entire supply chain to comply**
- NASA leverages products from many industrial sectors
- **AS9100 is too general.** Some gaps are filled by invoking technical standards (but not all). Customized SOW language is needed (future: new industry std?)

Subassemblies, Functional Systems, Mission
Payloads, Spacecraft, Aircraft, Launch Systems:
AS9100

Everything else:
(Future: IA9130?)

ISO 9001

AS9003

ISO/IEC17025

Nadcap

IPC

QML

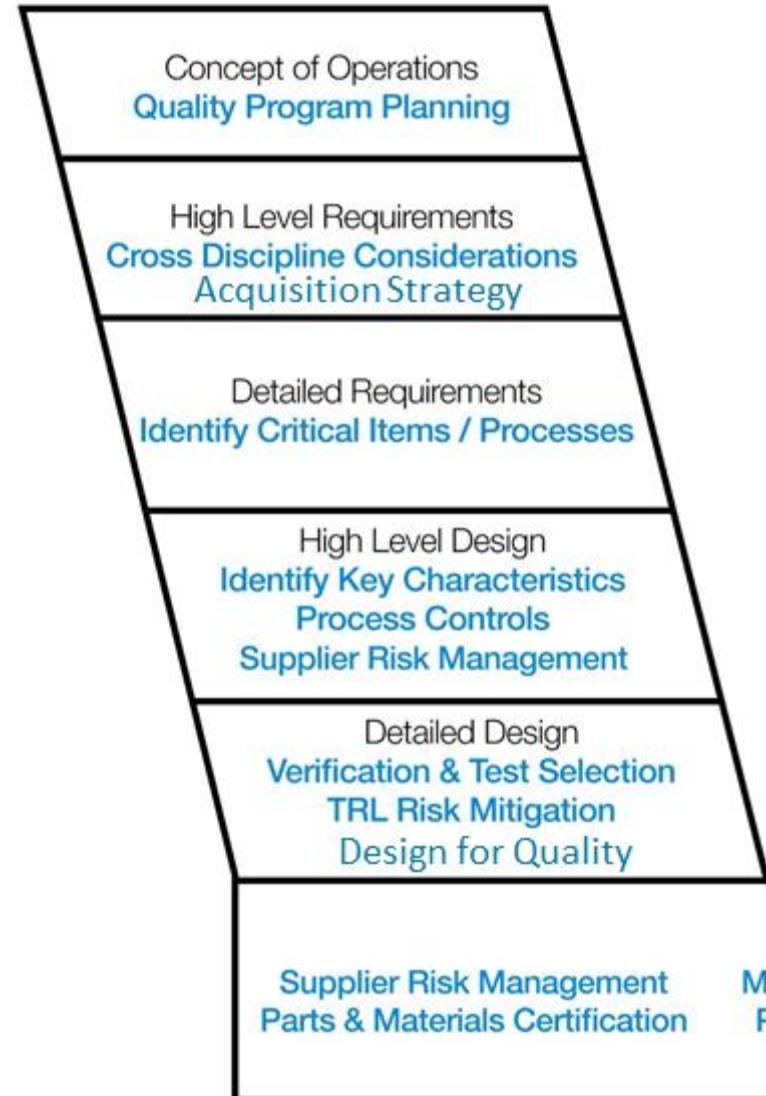
Requirements

1. Quality System
2. Quality System Changes and Finding Requirements
3. Supplemental Requirements Flowdown
4. Quality Records
5. Sale, Relocation, or Closure of Seller's Facility or Transfer of Manufacturing Operations
6. Supplier Change Control
7. Supplier Change Control: For Seller Design Authority and COTS Products
8. Language
9. Counterfeit Parts / Materials Prevention
10. Government-Industry Data Exchange Program (GIDEP) Membership
11. Calibration
12. Facility Access
13. Corrective Action, Preventive Action, Request and Reporting
14. Control of Nonconforming Product / Material Review Process
15. Special Process - Requirements

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- 4 Discover low TRL processes, and parts and materials selections that will drive up Supply Chain risk



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Find Design-for-Manufacturability threats

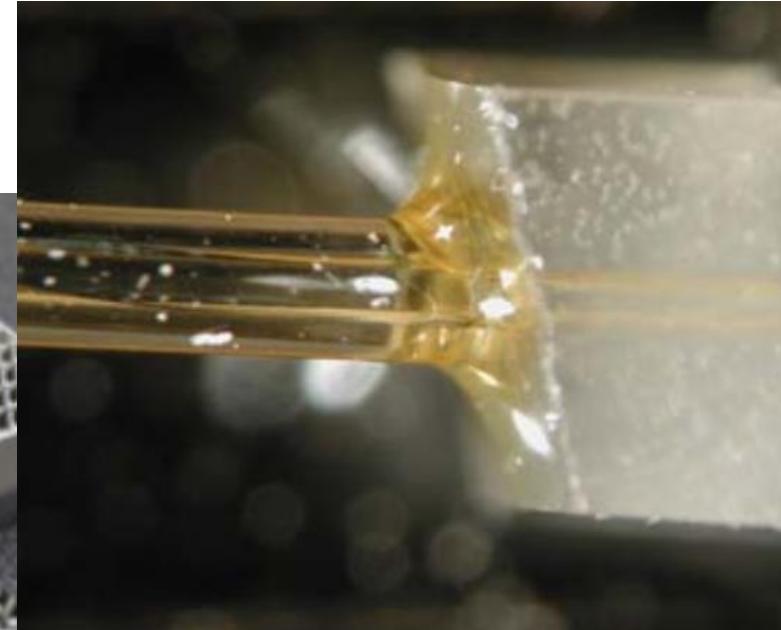
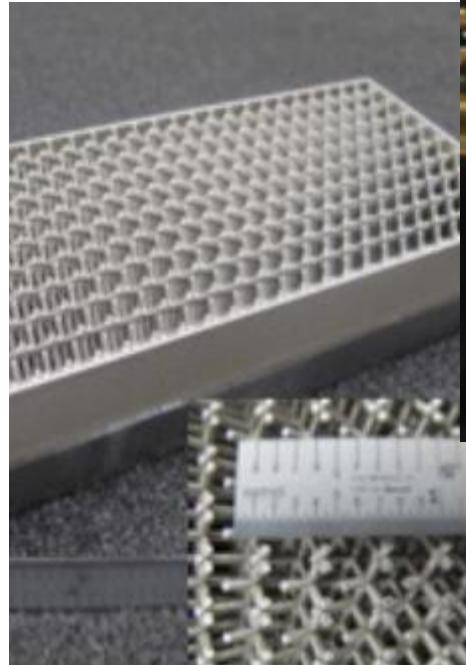
From:

- Low TRL
- Ultra-low volume:
 - Unique designs [for science]
 - Non-standard and made “in-house”
 - Workaround for obsolescence
- No technical standard
- Rework and repair

The threat may also be programmatic: Availability of necessary materials, fixturing, capital equipment

Programmatic threat (time, \$\$)

- Incomplete understanding of process + higher reliance on lot-based destructive testing (schedule hit=\$\$)
- Indecisiveness about accept/reject criteria

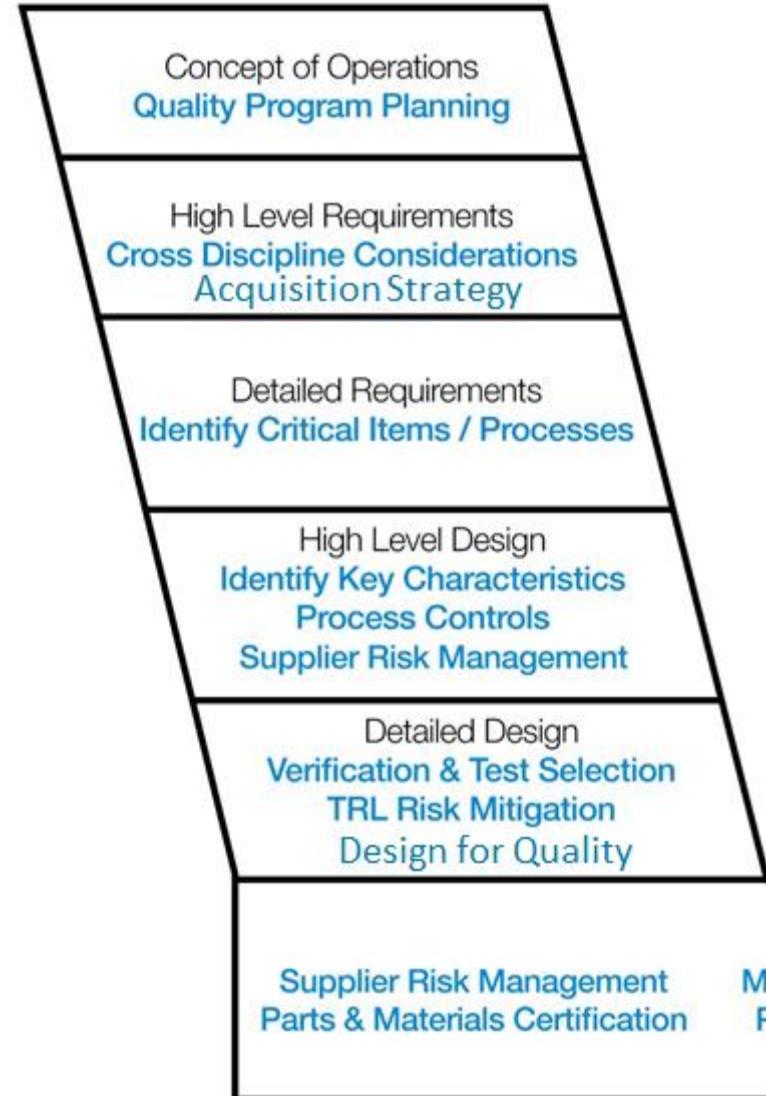


Combine learning about how designs achieve performance objectives with getting a closer look at manufacturability and process maturity.

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- 3 Provide for good requirements flowdown past the Prime and Major Subcontractors
- 4 Discover low TRL processes, and parts and materials selections that will drive up Supply Chain risk
- 5 Ensure that Quality risks can be elevated to the formal risk management process



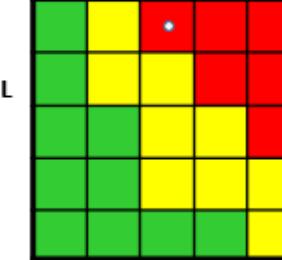
Ensure All Types of Quality Risks can be Elevated to Formal Risk Management

Early lifecycle stages offer the greatest opportunity to off-ramp risks and reduce cost.

Risks can emerge at any time. Risks that emerge early may be relate more to low fidelity strategies or requirements and can be mitigated with more planning/discussions.

Early risks may be:

- Insufficient QA team staffing
- Poor quality data management plans and infrastructure
- No effort to self-evaluate how the quality plan is being executed
- Creating an RFP before the quality plan is documented
- Early PO procurements that predate the quality requirements
- Supplier concerns, industrial base concerns, events that disrupt the supply chain

Prog/Proj Name Risk ID: OSMAQA-2019-002	Risk Title: Insufficient LCR Attention to Program/Project QA Program Implementation
Approach: Mitigate	Risk Statement: GIVEN THAT the Life Cycle Review (LCR) and Milestone Review processes are the dominant processes used by NASA to evaluate Program and Project (P/p) progress, challenges, risks, and risk management, and that these processes are defined primarily for the systems engineering domain, THERE IS A POSSIBILITY THAT Quality Program elements are not adequately reviewed, quality risks are not sufficiently elevated, and significant quality program weaknesses are undiscovered early enough to make corrections, WITH THE RESULT THAT significant quality problems become more likely.
Criticality: 	TECHNICAL CONSEQUENCE: Latent defects (i.e., embedded problems) prevent mission success.
Planned Transfer to Mission Directories: 12/30/21	PROGRAMMATIC CONSEQUENCES: <ul style="list-style-type: none">• Cost and schedule impacts prevent mission success.• Programs and projects with weak QA Programs are not discovered in time for effective risk mitigation.• NASA QA policy has less visibility and understanding.
L x C: 5 x 3 Status: Candidate Type: Technical	Context: NPR 7123.1 provides guidance to P/p for planning and conducting LCR reviews. These instructions significantly influence the both the P/p's and the review panel's baseline understanding of acceptable P/p maturity at different life cycle points. ...Continued on the next page
 Risk Originator: Jeannette Plante, OSMA, MASC 11/26/19	Likelihood: 5 P/p Quality Program maturity is currently not a subject of LCR or milestone reviews. Consequence: 3 The likelihood of a preventable quality problem is increased.
Risk Criticality :   	



Look for Programmatic threats that can be mitigated via design and supply chain management decisions. Fill QE technical capabilities gaps. Understand what challenges Program management, Design, and Procurement are facing. Keep attention on quality risks related to these areas.

Build in Quality

- **Context: Mission Objectives, Risk Posture**
- **Acquisition Strategy**
- **SCRM**
- **Manufacturability**
- **Risk management**

